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(54) **CARBON CLUSTER, RAW MATERIAL FOR PRODUCING THE SAME AND  
PRODUCTION OF THE SAME CARBON CLUSTER**

(57)Abstract:

PROBLEM TO BE SOLVED: To produce a new carbon cluster and a raw material for producing the carbon cluster and provide a method for producing the carbon cluster and further a method for extracting MC60 and MC70.

SOLUTION: This new carbon cluster is the one having a composition of SrC60 and SrC70. The carbon cluster is produced by adding a strontium compound such as strontium oxide to a carbonaceous raw material, using the resultant mixture as a raw material and carrying out the arc discharge, etc., thereof. MC60 and MC70 (M is a metal except Sr) are extracted from a soot containing both with aniline.

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CLAIMS

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[Claim(s)]

[Claim 1] The carbon cluster characterized by having the presentation of SrC60 and SrC70.

[Claim 2] The raw material for manufacturing the carbon cluster which contains SrC60 and SrC70 or it changes from SrC60 and SrC70 which are characterized by adding a strontium compound to a carbonaceous raw material.

[Claim 3] The manufacture approach of the carbon cluster characterized by obtaining the carbon cluster which contains SrC60 and SrC70 or it changes from SrC60 and SrC70 to a carbonaceous raw material using the raw material which added the strontium compound.

[Claim 4] The manufacture approach of the carbon cluster according to claim 3 characterized by manufacturing the carbon cluster which contains SrC60 and SrC70 or it consists of SrC60 and SrC70 by arc discharge.

[Claim 5] The manufacture approach of the carbon cluster according to claim 3 characterized by extracting the carbon cluster which contains SrC60 and SrC70 or it consists of SrC60 and SrC70 by the aniline.

[Claim 6] The manufacture approach of the carbon cluster which has the presentation of MC60 and MC70 which are characterized by extracting the carbon cluster which contains MC60 and MC70 or it consists of MC60 and MC70 by the aniline (however, M is the metal of an except about Sr.).

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## DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the approach of manufacturing the carbon cluster which has the presentation of MC60 and MC70 further, about the approach of manufacturing the raw material for manufacturing a new carbon cluster especially the carbon cluster which has the presentation of SrC60 and SrC70, and this carbon cluster, and its carbon cluster.

[0002]

[Description of the Prior Art] Various kinds of carbon clusters including the so-called fullerene of C60 by which the carbon cluster was discovered by the clo toe (Kroto) of Rice University, Smalley and others (Smalley) in 1985, or C70 grade are discovered until now, and the physical properties and the manufacture approach of a carbon cluster have come to be briskly studied all over the world. For example, if a potassium (K) is doped to C60 thin film by Hebard and others [A.F. Hebard et al., Nature, 350,600 (1991)], becoming the superconductor of critical temperature  $T_c=18K$  is discovered, and it is reported by Tanigaki and others [K. Tanigaki et al., Nature, 352,222 (1991)] that it is the superconductor whose  $Cs_2 RbC_{60}$  is  $T_c=33K$ . Moreover, it is reported by Friedman and others (S.H. Friedman et al., J. Am. Chem. Soc., and [115, 6506] (1993)) that C60 (water solubility) which added a certain kind of substituent suppresses growth of Homo sapiens immune disorder UISURU (HIV).

[0003] Moreover, the metal endocyst cluster which connoted the metal atom in the cage of a carbon cluster which is a kind of the carbon cluster containing a hetero atom is the type of a super-atom, according to the structure of the element by which endocyst is carried out, or the cluster to connote, it is expected that various physical properties are shown and the useful property is expected. The above-mentioned superconductivity was mentioned as one of the properties expected, and the metal endocyst cluster is comparatively stable in atmospheric air to the carbon cluster which doped the metal being unstable in atmospheric air. Therefore, the meaning is very large if what has a superconductivity by the metal endocyst cluster is discovered. In addition, as for the metal endocyst cluster, the application of a quite large field is expected on the industry of a semiconductor material, an electrical conducting material, a magnetic material, etc.

[0004] As mentioned above, the interest about current and a metal endocyst cluster is high, and various kinds of researches are advanced briskly. For example La@C82, Shinohara and Sato [H. Shinohara which connoted the lanthanum (La) atom to the carbon cluster C82 by Smalley, CHAI and others (R.E. Smalley, Y. Chai et al., J. Phys. Chem., and [95, 7564] (1991)), H. -- Sato et Y@C82 which connoted the yttrium (Y) atom to the carbon cluster C82 by al., J. Phys. Chem., 96, and 3571 (1992)], or Y2 @C82 -- the same -- Shinohara and Sato [H. Shinohara -- H. Sato et al., Nature, 357, Sc@C82 that connoted the scandium (Sc) atom to the carbon cluster C82 by 52 (1992)], Sc2 @C82, Sc3 @C82, and GIRAN [E.G. Gillan et al. To the carbon cluster C82 by al., J. Phys. Chem., 96, and 6869 (1992)], cerium (Ce), Neodmium (Nd), samarium (Sm), a europium (Eu), A gadolinium (Gd), a terbium (Tb), a dysprosium (Dy), There is a report of generation of the various metal endocyst clusters which connoted each atom of a holmium (Ho) and an erbium (Er), and it is known that the endocyst of most periodic-

table III A group metals will be carried out into a carbon cluster C82 or C84. Organic solvents, such as carbon disulfides including La@C82, Y@C82, and Gd@C82 and toluene, can extract the metal endocyst carbon clusters C82 various [ these ] and C84, it is isolated by separation and purification, and research on the physical properties is being advanced.

[0005] Furthermore, to a carbon cluster C28 or C60 in recent years by Smalley, GUO and others (R.E.Smalley, T.Guo et al., Science, and [257, 1661] (1992)) Uranium (U), Generation of U@C28, U@C60, Hf@C28, Zr@C28, and Ti@C28 which connoted the hafnium (Hf), the zirconium (Zr), and the titanium (Ti) atom is reported. By moreover, Smalley or one [under R.E.Smalley, L.S.Wang et al., Z.Phys., D, and printing] The carbonaceous raw material which added the calcium oxide (CaO) 0.3% by the atomic ratio to carbon is used, calcium@C60 is generated in arc discharge, and it is reported that it can extract with a carbon disulfide. Moreover, it is reported by collections of the 10th fullerene synthesis symposium lecture summaries, such as Taji [Kazuyuki Taji and Hideshi etc. Takahashi, P150, and 1996] that La@C60, Y@C60, Gd@C<SUB>60, Ce@C60, Pr@C60, etc. were generated. Thus, recently, although a class has little various metal endocyst carbon cluster M@C60 compared with various metal endocyst carbon cluster M@C82, the generation is beginning to be checked steadily. However, even if generated, as for what can be extracted with a solvent, only calcium@C60 was not checked until now, but implementation of the effective solvent extraction approach was demanded also to the new generation of metal endocyst carbon cluster M@C60 which can be extracted with a solvent, and further known M@C60.

[0006]

[Problem(s) to be Solved by the Invention] Although wholeheartedly experimented for the purpose of the generation of a metal endocyst carbon cluster from which this invention person etc. can become [ former ] new materials about various alkali metal and alkaline earth metal paying attention to a superconductivity being observed by doping to a carbon cluster C60, and an extract, the desired end is reached about strontium (Sr) at last. That is, although expected as the compound which has the new property which is not until now, and new materials also to the strontium atom content carbon cluster which has the presentation of SrC60 and SrC70, generation of SrC60 and SrC70 was not reported and was not able to confirm the useful property expected until now. Then, this invention aims at offering the extract approach which was excellent in MC60 and MC70 which were discovered by coincidence until now for the purpose of offering the raw material for manufacturing the strontium atom content carbon cluster which has the presentation of SrC60 and SrC70 which are a new carbon cluster, and this carbon cluster, and the manufacture approach of that carbon cluster.

[0007]

[Means for Solving the Problem] The carbon cluster concerning this invention is a carbon cluster which has the presentation of SrC60 and SrC70. This carbon cluster can be manufactured if the raw material which added the strontium compound is used for a carbonaceous raw material. There are an approach (arc discharge method) of evaporating a raw material by arc discharge in inter-electrode [ this ] by using as a raw material the electrode which consists of a carbonaceous ingredient what is necessary being just the approach of manufacturing the carbon cluster known from the former as an approach of manufacturing this carbon cluster, a method (resistance heating method) of passing a high current in a carbonaceous raw material, and evaporating a raw material, a method (laser evaporation method) of evaporating a raw material by laser radiation, etc.

[0008] With the carbonaceous raw material concerning this invention, it may consist of carbon substantially, in addition the unescapable impurity element, for example, Si, Fe, V, Na, aluminum, nickel, Pb, Cr, Mg, Ti, S, P, N, etc., may be included on manufacture. This invention uses for such a carbonaceous raw material a kind or the raw material which mixed two or more sorts and was added for strontium compounds (however, in this invention, a strontium simple substance shall also be included in a strontium compound), such as carbonates, such as a strontium carbonate, a strontium oxide, and strontium fluoride, a sulfate, a nitrate, acetate, phosphate, an oxalate, a fluoride, a chloride, a bromide, an iodide, an alkylation object, and an organic compound, and manufactures a carbon cluster.

[0009] And the strontium which exists in the raw material for manufacturing SrC60 and SrC70 may

exist as a gestalt of the added strontium compound as a gestalt which carried out the chemical bond to raw material carbon. However, in order to make it the effectiveness show up in homogeneity, as for the strontium which exists in a raw material with any gestalt, it is desirable that carbon and strontium are intermingled in homogeneity. As this raw material, shaping and the ingredient which heat-treated it further can use the mixture of a strontium compound and carbonaceous powder, and them. Moreover, not only a Plastic solid but it may be powdered.

[0010] Next, the typical manufacture approach of the raw material concerning this invention is described in a detail below.

[0011] As a strontium compound, the thing of the shape of a solid-state, a liquid, or a gas is mentioned. When using a solid thing, in order to make a strontium compound intermingled in homogeneity, it is desirable to use what carried out disintegration to powder with a mean particle diameter of 0.1 micrometers - 1mm or its magnitude.

[0012] The various coke breezes by which calcining of petroleum systems, such as needle coke, regular corks, pitch coke, a fluid coke, and gilsonite coke, or the coal system was carried out, or calcining is not carried out if carbonaceous powder is mentioned concretely Various mesophase carbon powder, such as various carbon fiber powder, such as a PAN system and a pitch system, a meso carbon micro bead, and bulk mesophase, It can be adapted in what is used as the aggregate of a carbon material from the former, such as various carbon black powder, such as thermal black, furnace black, lamp black, and channel black, various vitrified carbon powder, various pyrolytic carbon powder, various artificial-graphite powder, and various natural-graphite powder. Moreover, if it burns, what changes to carbonaceous is usable. Since such carbonaceous powder makes it into what can mix a strontium compound to homogeneity, it is desirable to use what carried out disintegration to powder with a mean particle diameter of 0.1 micrometers - 1mm or its magnitude. What is necessary is for grinders, such as a hammer mill, a jet mill, and a ball mill, just to perform disintegration that what is necessary is just to carry out by the well-known approach.

[0013] As what combines such strontium compounds and carbonaceous powder, although it is not indispensable, when carbonaceous powder does not have self-caking, it is desirable to use the binder which does so an adhesion operation of various synthetic resin, such as various pitches, such as a coal-tar pitch and a petroleum system pitch, phenol resin, and furan resin, etc. It is because the effectiveness by addition of a strontium compound will become become easy to stick a strontium compound and carbonaceous powder, and is easy to be demonstrated if these binders are used.

[0014] Although various mixers, such as the Warner mold and a paddle wing mold, perform, and a heating kneader also uses together that what is necessary is just to perform mixing of the binder used a strontium compound, carbonaceous powder, and if needed by the well-known approach and usually being carried out at 100-250-degree about C temperature, as for this invention, it is needless to say that it is not what receives constraint special to mixed conditions, such as such mixers, temperature, etc.

[0015] Subsequently, according to a conventional method, die pressing is carried out, it fabricates by the approach of shaping, extrusion molding, oscillating molding shaping, the hydrostatic-pressure pressing between the colds, a hotpress, etc., and the secondary powder which ground the mixture of the binder used a strontium compound, carbonaceous powder, and if needed or its mixture is fabricated.

[0016] Even if the Plastic solid acquired in this way remains as it is, it can be used as a raw material for manufacturing SrC60 and SrC70, but since reinforcement is low, it is desirable to heat-treat at the temperature which is extent in which a strontium compound does not vaporize and evaporate, and to raise reinforcement. Usually, it heat-treats by 400-1500-degreeC. By this heat treatment, a binder functions as one component of the raw material for carbonizing and manufacturing SrC60 and SrC70 in complete harmony with a strontium compound or carbonaceous powder, and the reinforcement of a Plastic solid also becomes high further. This heat treatment is buried in packing materials, such as a coke breeze for preventing oxidation and deformation of a Plastic solid according to a conventional method using heating furnaces, such as an independent furnace, a continuous furnace, and a continuous furnace, and silica sand, or is performed under non-oxidizing atmospheres, such as nitrogen gas and argon gas.

[0017] Since many pores are formed of the vaporization of the volatile matter contained in carbonaceous powder or a binder by this heat treatment etc. and reinforcement and bulk density fall by it, a Plastic solid may infiltrate various pitches into a Plastic solid if needed, may plug up that pore, and may perform reheat processing further. Reinforcement and bulk density can be improved by this sinking-in / reheat processing.

[0018] On the other hand, it can sink in into an artificial-graphite object, a carbon Plastic solid, etc., and the ingredient which heat-treated if needed can also use a strontium compound as a raw material.

[0019] If mean particle diameter exceeds 100 micrometers when raw material carbon and a strontium compound manufacture a Plastic solid using a particle-like thing in the case of a Plastic solid, it will be hard coming to evaporate at the time of carbon cluster manufacture, and the particle omission by the spatter will increase, and degradation will be caused. If it sees from still more nearly another viewpoint, it will become easy to cause the fall of a Plastic solid on the strength, and the yield will also worsen. Therefore, when using a particle-like thing, it is desirable to manufacture a Plastic solid with powder with a mean particle diameter of 100 micrometers or less.

[0020] Moreover, as long as it is the range which does not check the purpose of this invention, regardless of the gestalt, other elements may exist in carbonaceous powder, the strontium compound, and the binder.

[0021] In the case of a Plastic solid, it sets, and bulk density is 1.00 Mg/m<sup>3</sup>. It becomes difficult to become porosity for it to be the following and to fix to a position in the case of use, and the particle omission by the spatter also increase. Furthermore, since there are few amounts of ingredients per unit volume, more counts of an activity are needed and economical efficiency also worsens. Moreover, the bulk density of a Plastic solid is 2.00 Mg/m<sup>3</sup>. If it exceeds, spalling resistance will deteriorate and it will also become the cause of becoming easy to generate a crack by the thermal shock at the time of being discharge, as a result producing breakage of a Plastic solid. therefore, the bulk density of a Plastic solid - 1.00 - 2.00 Mg/m<sup>3</sup> it is -- things are desirable.

[0022] Moreover, in manufacturing a carbon cluster with an arc discharge method in the case of a Plastic solid, when maintaining the reinforcement and thermal shock resistance which can be equal to discharge, the bending strength of 10 or more MPas is required, and it becomes easy to produce grain child omission lower than this. So, as for the bending strength of a Plastic solid, it is desirable that they are 10 or more MPas.

[0023] Such a Plastic solid is processed into a desired configuration if needed. For example, what is necessary is just to manufacture and process the Plastic solid of various configurations including the shape of a column, in considering as the raw material for an arc discharge method or resistance heating methods.

[0024] Moreover, in using an impalpable powder-like thing as the raw material for carbon cluster manufacture so that it may be represented by the technique given in JP,6-80410,A, it is sufficient if what mixed a strontium compound and carbonaceous powder, and the powder which ground the ingredient when the strontium compound had already existed in an ingredient are used.

[0025] Although what is necessary is just to adjust suitably the amount of the strontium compound added in the raw material for carbon cluster manufacture to arbitration by the carbon cluster generator or the generating approach, if strontium exceeds 10 mass sections to the carbon 100 mass section, the yield of soot will begin to fall a little, and if 20 mass sections are exceeded, a soot yield will fall remarkably. On the other hand, strontium cannot generate SrC<sub>60</sub> and SrC<sub>70</sub> carbon cluster so much under in the 0.02 mass section to the carbon 100 mass section, but the effectiveness of strontium compound addition stops being able to appear easily. Therefore, as strontium added to the carbon 100 mass section, it is desirable 0.02 - 20 mass section and to add a strontium compound so that it may become 0.2 - 10 mass section preferably especially.

[0026] The description of this invention is to use such a raw material, and as long as it is the range which does not check the purpose of this invention, regardless of the gestalt, other elements may exist in the raw material. Moreover, there is no constraint special about manufacture conditions, such as the configuration of a raw material, the manufacture approach of a carbon cluster, a manufacturing

installation, a pressure, an ambient atmosphere, and partner electrode material.

[0027] In this way, if a carbon cluster is manufactured by the arc discharge type, the resistance heating type, a laser evaporation type, etc. using the raw material which added the strontium compound, in the process in which a strontium atom is disassembled from a strontium compound, he will contain in C60 and C70 in the middle of generation, and it will be thought that the carbon cluster of SrC60 and SrC70 is generated.

[0028] In this way, the soot containing MCs60 other than the soot containing obtained SrC60 and SrC70 carbon cluster and the strontium obtained by the known approach and MC70 carbon cluster can be extracted by the aniline using a Soxhlet extractor, high performance chromatography etc. can separate, and MCs60 other than the carbon cluster which has the presentation of SrC60 and SrC70, and strontium, and MC70 carbon cluster can be obtained. In addition, the extract was not able to be checked although the possibility of the use was tried about solvents, such as benzene, toluene, and a carbon disulfide, as an extracting solvent besides the aniline.

[0029]

[Example] Hereafter, an example explains this invention still more concretely.

[0030] As opposed to the example 1 artificial-graphite powder [Toyo Tanso make and ash content 0.01 mass % and mean particle diameter of 5-15 micrometers] 100 mass section The thing 3.24 mass section which ground the strontium oxide (SrO) [the Mitsuwa Chemicals make and 97% of purity] in mean particle diameter of 20 micrometers, Furthermore, methyl alcohol and furfuryl alcohol are added an amount (about 10 mass section) a little, and after adding the about 50 mass section and mixing further novolak phenol resin [the product made from Sumitomo DEYURESU] after mixing by Z mold mixer, mixing was completed with the hot calender roll (about 100-degreeC). Secondary grinding of this mixture was carried out so that mean particle diameter might be set to 30-60 micrometers. This secondary powder was performed by pressure 98MPa, metal mold shaping was performed at the room temperature, and the Plastic solid was acquired. Then, the Plastic solid was packed into final-stage powder (carbon powder) using iron sagger, and it calcinated by 800-degreeC temporarily. Furthermore, it heat-treated by 1100-degreeC in the vacuum. The obtained ingredients were bulk density 1.5 Mg/m3 and bending strength 19 MPa and specific resistance [ of 38micro ] ohm-m (room temperature).

[0031] This ingredient was used as an anode plate electrode of the manufacturing installation of an arc discharge method, and arc discharge was performed according to the conventional method. The discharge current and the electrical potential difference in this case made the inside of 80A, 25V, and the chamber of equipment the helium ambient atmosphere, and that pressure was set to 100Torr(s). The soot generated by this arc discharge was collected. Furthermore, the result of having extracted the collected soot by the aniline and having investigated the extract solution with the laser desorption time-of-flight mold (LD-TOF) mass spectrometer is shown in drawing 1 .

[0032] Since the peak respectively strong against the location of the mass number 928 corresponding to SrC70 again was detected besides C60 and C70 in the location of the mass number 808 corresponding to SrC60, the carbon cluster which has the presentation of SrC60 and SrC70 generates, and it can check being extracted, so that clearly from drawing 1 . Moreover, it can be surmised from having not broken, even if it ionizes that it is carbon cluster Sr@C60 and Sr@C70 which connoted strontium, respectively.

[0033] Each oxide mixing carbon rod of example 2 yttrium (Y), a lanthanum (La), a gadolinium (Gd), a cerium (Ce), PURASEOJIUMU (Pr), neodium (Nd), barium (Ba), and calcium (calcium) was used as an anode plate electrode, and the soot which performed arc discharge and was generated on the same conditions as an example 1 was collected, respectively. An aniline extracts the collected soot, respectively and the result of having investigated the extract solution with the laser desorption time-of-flight mold (LD-TOF) mass spectrometer is shown in drawing 2 - drawing 9 .

[0034] Since the peak respectively strong against the location of the mass number 929 corresponding to YC70 again was detected besides C60, C70, C74, and C76 in the location of the mass number 809 corresponding to YC60 so that clearly from drawing 2 , it can check that the carbon cluster which has the presentation of YC60 and YC70 is extracted. Moreover, it can be surmised from having not broken, even if it ionizes that it is carbon cluster Y@C60 and Y@C70 which connoted the yttrium, respectively.



[0035] Since the peak respectively strong against the location of the mass number 979 corresponding to LaC70 again was detected besides C60 and C70 in the location of the mass number 859 corresponding to LaC60 so that clearly from drawing 3 , it can check that the carbon cluster which has the presentation of LaC60 and LaC70 is extracted. Moreover, it can be surmised from not breaking, even if it ionizes that it is carbon cluster La@C60 and La@C70 which connoted the lanthanum, respectively.

[0036] Since the peak respectively strong against the location of the mass number 997 corresponding to GdC70 again was detected besides C60 and C70 in the location of the mass number 877 corresponding to GdC60 so that clearly from drawing 4 , it can check that the carbon cluster which has the presentation of GdC60 and GdC70 is extracted. Moreover, it can be surmised from having not broken, even if it ionizes that it is carbon cluster Gd@C60 and Gd@C70 which connoted the gadolinium, respectively.

[0037] Since the peak respectively strong against the location of the mass number 980 corresponding to CeC70 again was detected besides C60 and C70 in the location of the mass number 860 corresponding to CeC60 so that clearly from drawing 5 , it can check that the carbon cluster which has the presentation of CeC60 and CeC70 is extracted. Moreover, it can be surmised from having not broken, even if it ionizes that it is carbon cluster Ce@C60 and Ce@C70 which connoted the cerium, respectively.

[0038] Since the peak respectively strong against the location of the mass number 981 corresponding to PrC70 again was detected besides C60 and C70 in the location of the mass number 861 corresponding to PrC60 so that clearly from drawing 6 , it can check that the carbon cluster which has the presentation of PrC60 and PrC70 is extracted. Moreover, it can be surmised from having not broken, even if it ionizes that it is carbon cluster Pr@C60 and Pr@C70 which connoted PURASEOJUMU, respectively.

[0039] Since the peak respectively strong against the location of the mass number 984 corresponding to NdC70 again was detected besides C60 and C70 in the location of the mass number 864 corresponding to NdC60 so that clearly from drawing 7 , it can check that the carbon cluster which has the presentation of NdC60 and NdC70 is extracted. Moreover, it can be surmised from having not broken, even if it ionizes that it is carbon cluster Nd@C60 and Nd@C70 which connoted neodium, respectively.

[0040] Since the peak respectively strong against the location of the mass number 977 corresponding to BaC70 again was detected besides C60 and C70 in the location of the mass number 857 corresponding to BaC60 so that clearly from drawing 8 , it can check that the carbon cluster which has the presentation of BaC60 and BaC70 is extracted. Moreover, it can be surmised from having not broken, even if it ionizes that it is carbon cluster Ba@C60 and Ba@C70 which connoted barium, respectively.

[0041] a peak strong against the location of the mass number 760 corresponding to CaC60 besides C60, C70, C74, and C78 so that clearly from drawing 9 -- moreover, since the peak weak in the location of the mass number 880 corresponding to CaC70 was detected, it can check that the carbon cluster which has the presentation of CaC60 and CaC70 is extracted. Moreover, it can be surmised from having not broken, even if it ionizes that it is carbon cluster calcium@C60 and calcium@C70 which connoted calcium, respectively.

[0042] The ingredient which consists of carbonaceous 100% by the same approach as the approach of example 1 publication was manufactured except it without using example of comparison 1 strontium oxide. This ingredient was used as an anode plate electrode, and the soot which performed arc discharge and was generated on the same conditions as an example 1 was collected. As a result of a LD-TOF mass spectrometer's investigating the collected soot, but the conventional carbon cluster of C60 and C70 grade, nothing was undetectable.

[0043] Each oxide mixing carbon rod of example of comparison 2 yttrium, a lanthanum, a gadolinium, a cerium, PURASEOJUMU, neodium, barium, and calcium was used as an anode plate electrode, and the soot which performed arc discharge and was generated on the same conditions as an example 1 was collected, respectively. Although the carbon cluster to which all are expressed with Cn of C60 and C70 grade was detected as a result of three kinds of solvents', benzene's, toluene's, and a carbon disulfide's, extracting the collected soot, respectively and a laser desorption time-of-flight mold (LD-TOF's) mass spectrometer's investigating the extract solution, MC60 and MC70 were undetectable.

[0044]

[Effect of the Invention] By this invention, the carbon cluster which has the presentation of SrC60 and

SrC70 which are a new carbon cluster can be offered. Moreover, since these new carbon clusters SrC60 and SrC70, and MC60 and MC70 can be efficiently extracted by using an aniline, they can be easily isolated by the general purification after an extract, and separation actuation. Therefore, this invention is very useful for the use to an electrical conducting material, a semiconductor material, a superconducting material, a magnetic material, etc., or its physical-properties research.

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[Translation done.]